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*January 13, 2005*

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**APPLICATION NUMBER: 60/530,273**

**FILING DATE: *December 16, 2003***

**RELATED PCT APPLICATION NUMBER: *PCT/US04/42295***



Certified By

Jon W Dudas

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14230 U.S. PTO

PTO/SB/16 (08-03)

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## PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing

under 37 CFR 1.53(c).

Express Mail Label No.

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INVENTOR(S)					
Given Name (first and middle [if any])		Family Name or Surname		Residence (City and either State or Foreign Country)	
George Ernest		Dubois		San Luis Obispo, CA	
Additional inventors are being named on the <u>one</u> separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
Bicycle Crank Assembly					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
<input type="checkbox"/> Customer Number: <div style="border: 1px solid black; width: 200px; height: 30px;"></div>					
OR					
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages		<u>18</u>		<input type="checkbox"/> CD(s), Number _____	
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<input type="checkbox"/> Application Date Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.				FILING FEE Amount (\$)  <div style="border: 1px solid black; padding: 10px; text-align: center;">\$80.00</div>	
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
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14535 U.S. PTO  
60/530273

121603

Respectfully submitted,

[Page 1 of 2]

Date December 16, 2003

SIGNATURE

REGISTRATION NO. \_\_\_\_\_

(if appropriate)

Docket Number: \_\_\_\_\_

TYPED or PRINTED NAME George E. Dubois

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## USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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**INVENTOR(S)/APPLICANT(S)**

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[Page 2 of 2]

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# FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☒ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$ ) 80.00

**Complete if Known**

Application Number

Filing Date

First Named Inventor

Examiner Name

Art Unit

Attorney Docket No.

**METHOD OF PAYMENT (check all that apply)**☐ Check ☒ Credit card ☐ Money Order ☐ Other ☐ None☐ Deposit Account:Deposit  
Account  
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Deposit  
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☒ Charge fee(s) indicated below ☐ Credit any overpayments☒ Charge any additional fee(s) or any underpayment of fee(s)☐ Charge fee(s) indicated below, except for the filing fee to the above-identified deposit account.**FEE CALCULATION****1. BASIC FILING FEE**

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	80.00
SUBTOTAL (1)					(\$ ) 80.00

**2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE**

		Extra Claims		Fee from below		Fee Paid
Total Claims	<input type="text"/>	-20** =	<input type="text"/>	X	<input type="text"/>	<input type="text"/>
Independent Claims	<input type="text"/>	-3** =	<input type="text"/>	X	<input type="text"/>	<input type="text"/>
Multiple Dependent	<input type="text"/>				<input type="text"/>	<input type="text"/>

Large Entity		Small Entity		Fee Description
Fee Code	Fee (\$)	Fee Code	Fee (\$)	
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) (\$ ) 0.00

\*\*or number previously paid, if greater; For Reissues, see above

**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

Large Entity | Small Entity

Fee Code	Fee (\$)	Fee Code	Fee (\$)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for <i>ex parte</i> reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify)

\*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) (\$ ) 0.00

**SUBMITTED BY**

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Dec. 16, 2003

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Provisional Patent Application

of

**George E. Dubois and**

**Garrett A. Smith**

for

**BICYCLE CRANK ASSEMBLY**

## FIELD

The present invention pertains to a crank assembly for bicycles and, more particularly, to various features of such an assembly that reduce the number of parts, simplify assembly, decrease manufacturing cost, and improve the bearing life of such an assembly.

## BACKGROUND

Bicycling is a sport that requires transferring force from the rider's legs to a driving chain that propels the bicycle. These forces are transmitted to the chain by means of crank arms, which are typically attached to a bearing assembly known as a bottom bracket rotatably installed in a shell of a bicycle frame. Typically the crank arms are attached to both ends of the bottom bracket spindle and are each removable from said spindle. The bottom bracket spindle is rotatably mounted to the bicycle frame by bearings typically located inside the frame shell. Since the bearings are typically located inside the bicycle frame shell, their size is governed by the size of the shell. The size of the frame shell also consequently governs the diameter of the bottom bracket spindle.

It is desirable to increase the diameter of the bottom bracket spindle and the bearings that rotatably mount it to the bicycle frame. Increasing the size of the spindle increases its strength and stiffness while increasing the bearing size allows for longer-lasting more durable bearings.

It is also desirable for assembly of the crank arms and bottom bracket to be as simple and robust as possible. Typical crank assemblies require each crank arm to be assembled onto each spindle end after the bearing units are installed into the frame. This complicates assembly, results in many joints between assembly parts, and leads to high part counts. Variances in frame shell tolerances or assembly procedures can cause problems with crank assemblies that are not designed to accommodate these tolerances.

Another problem related to assembly involves alignment of the bearing races. To maximize bearing life of the bottom bracket it is critical that the bearing races be correctly aligned such that the bearings are not subjected to additional axial loading due to part tolerances or assembly procedures. Bearings that are over-loaded quickly fail. Most current bearing assemblies require tight tolerances or strict assembly procedures to prevent bearing from becoming axially over-loaded.

Further, typical bottom bracket systems use the same size and method of loading for each bearing unit used in bottom bracket. However, this makes it impossible to balance the loads placed upon the bearings so that bearing life is maximized. Also, most spindles are integrated within the bearing units themselves such that when the bearings wear out the entire unit must be replaced.

## OBJECTS OF THE INVENTION

The objects of the invention are to provide a bicycle crank assembly:

- a) with the fewest number of pieces and interfaces between pieces such that manufacturing cost is minimized;

- b) in which both bearings of the assembly are located outboard from the frame shell such that their size and the size of the bottom bracket spindle is not constrained by said frame shell;
- c) that is simple to install and robust with respect to installation procedure variations;
- d) that is easy to disassemble for routine maintenance;
- e) that does not rely on assembly tolerances or procedures to adjust the axial bearing loads and can accommodate large tolerance deviations of the frame shell;
- f) that balances the loading of the bearing units such that bearing life for the system is maximized;
- g) that is well sealed to protect the bearings from contamination yet still allows an escape path for contaminants that may get through the seal system, such that the potential for bearing damage is minimized.

## SUMMARY OF THE INVENTION

The present invention is directed to a bicycle crank assembly that achieves the above objectives. The preferred embodiment of the present invention comprises a spindle integral with a drive crank arm, a non-drive crank arm, and two bearing assemblies. Both bearing assemblies are installed in a bicycle frame such that the bearings are located outboard in an axial direction from the outer surfaces of the frame shell. The drive crank arm with its integrated spindle is slid through both bearing assemblies and the non-drive crank arm is then assembled onto its free end. The inner race of the bearing assembly located closest to the non-drive crank arm is clamped between a shoulder on the spindle



and a side surface of the non-drive crank arm by tightening a bolt system. In this way the assembly consists of few parts, has only one joint connecting the parts together, is simple and robust to install, is not affected by variations in the width of the frame shell, and balances the loading between bearing units such that bearing life is maximized.

Another embodiment of the present invention is similar to the preferred embodiment except that the drive crank arm is formed from a fiber-resin composite material and integrally bonded with the spindle. In this way the number of parts is further reduced and the assembly made very lightweight through the effective use of composite materials.

Yet another embodiment of the present invention is similar to the preferred embodiment except the drive crank arm and spindle are formed monolithically as one piece. In this way the number of parts is further reduced and the strength is increased while maintaining the same benefits as the original embodiment.

In the preferred embodiment of the bearing assemblies used to rotatably mount the spindle to the frame, the bearing assembly comprises of a bearing adapter, a cartridge bearing unit, and an external seal. The cartridge bearing unit is of a standard design and comprises an inner bearing race, outer bearing race, a plurality of rolling bearing elements, and at least one seal. The seal on the cartridge bearing unit is designed such that it rotates with the outer bearing race and rubs against the inner bearing race. In contrast, the external seal on the bearing assembly is designed to rotate with the inner bearing race and spindle and rub on its outer diameter against the bearing adapter. In this way the bearing assembly is protected from the elements by a two-seal system. The two-seal system, with the cartridge bearing seal rubbing on its inner diameter and the external

seal rubbing on its outer diameter act together to minimize the potential for contamination of the bearings while allowing any water that might enter the external seal to be easily expelled.

In the preferred embodiment of the bolt system used to tighten the non-drive crank arm onto the spindle the bolt consists of a threaded portion and flanged portion. The outer surface of the flange portion is tapered conically relative to the bolt axis. The system further comprises a cup threaded into the non-drive crank arm exterior to the bolt flange such that the bolt lies between a flange on the cup and the non-drive crank arm. An inner flange surface of the cup is conically tapered relative to the bolt axis such that it can mate with the corresponding conically tapered bolt flange. When the bolt is unscrewed, the cup acts as an axial stop whereby unscrewing the bolt extracts the non-drive crank arm from the spindle. In this manner the assembly is easily disassembled, the bolt is always contained within the non-drive crank arm such that it cannot get lost, and the height of the bolt and cup system is minimized thereby increasing ankle clearance for the rider.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**Figure 1** is a side view of a bicycle that includes a particular embodiment of a crank assembly according to the present invention.

**Figure 2** is a rear cross-sectional view of the preferred embodiment of a crank assembly according to the present invention.

**Figure 3A** is an isometric partial cross-sectional view of the preferred embodiment of a bearing adapter shown in **Figure 2**.

**Figure 3B** is an isometric partial cross-sectional view of the preferred embodiment of a bearing adapter shown in **Figure 2**.

**Figure 4A** is a cross-sectional view of the preferred embodiment of the seal shown in **Figure 3A**.

**Figure 4B** is a cross-sectional view of the preferred embodiment of the seal shown in **Figure 3B**.

**Figure 5** is an isometric partial cross-sectional view of the preferred embodiment of the drive crank arm and integrated spindle shown in **Figure 2**.

**Figure 6** is an isometric partial cross-sectional view of the preferred embodiment of the non-drive crank arm shown in **Figure 2**.

**Figure 7A** is an isometric partial cross-sectional view of the washer shown in **Figure 2**.

**Figure 7B** is an isometric partial cross-sectional view of the bolt shown in **Figure 2**.

**Figure 7C** is an isometric partial cross-sectional view of the cup shown in **Figure 2**.

**Figure 8** is an isometric partial cross-sectional view for an alternate embodiment of the drive crank arm and integrated spindle shown in **Figure 5**.

**Figure 9** is an isometric partial cross-sectional view for another alternate embodiment of the drive crank arm and integrated spindle shown in **Figure 5**.

#### DETAILED DESCRIPTION OF THE EMBODIMENTS

**Figure 1** is a side view of a bicycle 10 that incorporates a particular embodiment of a crank assembly according to the present invention. Bicycle 10 may be any type of bicycle and in this embodiment comprises a typical frame 11 including a frame shell 12. A crank assembly 20 is rotatably mounted to frame shell 12. Chain 13 engages at least one chainwheel 49 attached to drive crank arm 40 and at least one sprocket 14 attached to rear wheel 15. Thus bicycle 10 is propelled by rider generated forces propagating through chainwheel 49, chain 13, sprocket 14, and rear wheel 15.

**Figure 2** is a rear cross-sectional view of the preferred embodiment of a crank assembly 20 rotatably mounted to frame shell 12. Crank assembly 20 comprises bearing assemblies 30a, 30b, spacer tube 39, drive crank arm 40 integral with spindle 50, and non-drive crank arm 60. Non-drive crank arm 60 is attached to the free end of spindle 50

via an interface portion 61 which mates to spindle interface portion 52. Bolt 70 holds non-drive crank arm 60 onto spindle 50.

**Figure 3A** shows the preferred embodiment of bearing assembly 30a, comprising cartridge bearing unit 31a, bearing adapter 32a, and external seal 80. Bearing adapter 32a comprises flanged portion 34a and threaded portion 35a. Threaded portion 35a mates with corresponding threads in frame shell 12 and is tightened until flange portion 34a contacts the outside face 12a of frame shell 12. Cartridge bearing unit 31a is press-fit inside flange portion 34a of bearing adapter 32a such that bearing 31a is located distally outboard from the outside face 12a of frame shell 12. Cartridge bearing unit 31a is of standard design and comprises outer race 301, inner race 302, seals 303, and a plurality of rolling bearing elements 304. Seals 302 are designed to be rotatably fixed to outer race 301 such that seal 302 rubs on its inner diameter against inner race 302.

**Figure 3B** shows the preferred embodiment of bearing assembly 30b, comprising cartridge bearing unit 31b which is identical to cartridge bearing unit 31a, bearing adapter 32b, external seal 90, and bearing reducer 33. Bearing reducer 33 comprises flange portion 33a and cylindrical portion 33b. Cylindrical portion 33b of bearing reducer 33 is press-fit into cartridge bearing unit 31b from the inside out until flange portion 33a contacts the inner race of cartridge bearing unit 31b. In this way the same size cartridge bearing can be used in both bearing assemblies 30a and 30b. In an alternative embodiment cartridge bearing unit 31b may be sized differently than cartridge bearing unit 31a such that bearing reducer 33 is not needed. In this case the inner race diameter of cartridge bearing unit 31b would be smaller than the inner race 302 diameter of cartridge bearing unit 31a.

Bearing adapter **32b** comprises flanged portion **34b** and threaded portion **35b**. Threaded portion **35b** mates with corresponding threads in frame shell **12** and is tightened until flange portion **34b** contacts the outside face **12b** of frame shell **12**. In this particular embodiment cartridge bearing unit **31b** is identical to cartridge bearing unit **31a** and is press-fit inside flange portion **34b** of bearing adapter **32b** such that cartridge bearing unit **31b** is located distally outboard from the outside face **12b** of frame shell **12**.

It has been discovered that due to pedaling loads applied to the crank arms and the resulting chain forces generated through chainwheel **49**, that bearing assembly **30a** has greater radial force applied to it than bearing assembly **30b**. This results from the fact that chainwheel **49** is closest to bearing assembly **30a** and farthest from bearing assembly **30b**. Thus, the sum of the radial forces on the bearing assembly closest to chainwheel **49** consists of the forces going through chainwheel **49** plus the loads due to pedaling and this force sum is highest on the bearing assembly closest to chainwheel **49** and lowest on the bearing assembly farthest from chainwheel **49**. Since bearing life increases if the loading on the bearing is minimized, it is desirable to balance the forces applied to bearing assemblies **30a** and **30b** such that the total loading for each bearing assembly is minimized. Thus it has been discovered that bearing assembly **30b** should carry the additional axial forces such that these forces do not pass through the higher loaded bearing assembly **30a**. To broaden this concept, it is an important discovery of the present invention that the bearing assembly located farthest from chainwheel **49** should carry both axial and radial loads, while the bearing assembly closest to chainwheel **49** should carry only radial loads. In this way the bearing life of crank assembly **20** is maximized.

The present invention accomplishes this though clever assembly design as will be discussed in more detail below.

**Figure 4A** is a cross-sectional view of the preferred embodiment of seal **80** which comprises rubber portion **81** and metal portion **82**. Rubber portion **81** comprises outer rubbing element **81a** and inner rubbing element **81b**. Flange portion **34a** of bearing adapter **32a** comprises groove **83** in which outer rubbing element **81a** of seal **80** is installed. Groove **83** is designed such that rubber portion **81** of seal **80** must be slightly deformed when it is installed into said groove **83**. Once installed rubber portion **81** will substantially return to its original shape and thus be retained inside groove **83**. Inner rubbing element **81b** is sized such that it is smaller in diameter than spindle **50** at the axial location of spindle **50** where inner rubbing element **81b** contacts spindle **50** when crank assembly **20** is completely installed. Groove **83**, outer rubbing element **81a**, inner rubbing element **81b**, and spindle **50** are all sized such that the friction between inner rubbing element **81b** and spindle **50** is greater than the friction between outer rubber element **81a** and groove **83**. Thus seal **80** is rotatably fixed to spindle **50** but free to rotate inside groove **83** of bearing adapter **32a**.

**Figure 4B** is a cross-sectional view of the preferred embodiment of seal **90** which comprises rubber portion **91** and metal portion **92**. Rubber portion **91** comprises outer rubbing element **91a**. Flange portion **34b** of bearing adapter **32b** comprises groove **93** in which outer rubbing element **91a** of seal **90** is installed. Groove **93** is designed such that rubber portion **91** of seal **90** must be slightly deformed when it is installed into said groove **93**. Once installed rubber portion **91** will substantially return to its original shape and thus be retained inside groove **93**. The inner diameter of metal portion **92** is sized

such that it is slightly larger in diameter than the inner diameter of bearing reducer 33. If an embodiment of crank assembly 20 does not include bearing reducer 33 then the inner diameter of metal portion 92 is sized such that it is slightly larger than the inner diameter of bearing 31b. In this way spindle 50 is easily inserted through bearing 31b without contacting seal 90.

Figure 5 is an isometric partial cross-sectional view of the preferred embodiment of drive crank arm 40 and integrated spindle 50. Drive crank arm 40 comprises pedal adapting portion 41, crank arm portion 42, and spindle adapting portion 43. Support projections 48 are provided on drive crank arm 40 for attaching at least one chainwheel 49 for driving a chain 13 to propel bicycle 10.

Spindle 50 comprises flange portion 51, drive adapting portion 52, bearing race portions 53a and 53b, shoulder portion 54, non-drive adapting portion 55, and threaded portion 56. In this particular embodiment drive adapting portion 52 comprises a plurality of splines for mating with a plurality of corresponding splines in spindle adapting portion 43 of drive crank arm 40. Similarly, non-drive adapting portion 55 comprises a plurality of splines for mating with a plurality of corresponding splines in spindle adapting portion 63 of non-drive crank arm 60. Non-drive adapting portion 55 is of a smaller diameter than drive adapting portion 52. Bearing race portion 53b is of smaller diameter than bearing race portion 53a with shoulder portion 54 disposed therebetween.

Spindle adapting portion 43 of drive crank arm 40 comprises cylindrical bore 44 inside of which are formed a plurality of splines 45 for meshing with drive adapting portion 52 of spindle 50. Flange 51 of spindle 50 abuts against an outer side surface of cylindrical bore 44. In this embodiment spindle 50 may be either press-fit into cylindrical



bore 44 or crank arm 40 may be heat-shrunk onto spindle 50. In this manner spindle 50 is integrated with drive crank arm 40 in a non-rotatable manner.

**Figure 6** is an isometric partial cross-sectional view of the preferred embodiment of non-drive crank arm 60. Non-drive crank arm 60 comprises pedal adapting portion 61, crank arm portion 62, and spindle adapting portion 63. Spindle adapting portion 63 comprises cylindrical bore 64 and inner side surface 64a. A plurality of splines 65 for meshing with non-drive adapting portion 55 of spindle 50 are formed on the interior of cylindrical bore 64. Splines 65 in cylindrical bore 64 and their corresponding splines on non-drive adapting portion 55 are tapered in an axial direction such that as non-drive crank arm 60 is installed onto the free end of spindle 50 the fit between the mating splines tightens. This ensures that non-drive crank arm 60 is tightly engaged with spindle 50 such that relative movement between them is prevented. Bolt 70 is used to draw non-drive crank arm 60 onto spindle 50 in an axial direction until inner side surface 64a contacts seal 90. Spindle adapting portion 63 further comprises cylindrical bore 66 terminating in outer side surface 67. Cylindrical bore 66 is larger in diameter than cylindrical bore 64 and has threads 68 formed on its interior. Outer side surface 67 is perpendicular to the axis of cylindrical bore 66.

**Figure 7A** is an isometric partial cross-sectional view of washer 74. Washer 74 comprises inner side surface 74a and outer side surface 74b. Inner side surface 74a mates against outer side surface 67 of non-drive crank arm 60.

**Figure 7B** is an isometric partial cross-sectional view of bolt 70 comprising flange portion 71, threaded portion 72, and tool-engaging portion 73. Threaded portion 72 mates with corresponding spindle threaded portion 56. Flange portion 71 comprises

inner side surface 71a and outer side surface 71b. Inner side surface 71a is perpendicular to the bolt axis and mates against washer outer side surface 74b. Bolt flange outer side surface 71b is at an angle  $\Omega$  relative to the bolt axis; in this particular embodiment angle  $\Omega$  is 60 degrees but may be anywhere between 40 and 75 degrees. The angle  $\Omega$  of outer side surface 71b allows cup 75 to be smaller in an axial direction than if the outer side surface 71b were perpendicular to the bolt axis because the contact area between bolt outer side surface 71b and cup inner side surface 77a is greater, thus reducing the contact stress. Tool-engaging portion 73 is formed on the inner bore of bolt 70 such that an un-shown assembly tool can non-rotatably engage bolt 70 for tightening. In this particular embodiment tool-engaging portion 73 is shaped for interfacing with a standard Allen wrench.

Figure 7C is an isometric partial cross-sectional view of cup 75 comprising threaded portion 76 and flange portion 77. Threaded portion 76 mates with corresponding non-drive crank arm threads 68. Flange portion 77 comprises inner side surface 77a and tool-engaging portion 78. Inner side surface 77a is orientated at an angle  $\Omega$  relative to the axis of threaded portion 76. Angle  $\Omega$  of inner side surface 77a matches that of bolt outer side surface 71b such that the two side surfaces mate together. Tool-engaging portion 78 is formed on the inner bore of flange 77. In this particular embodiment tool-engaging portion 78 comprises a plurality of splines for non-rotatably engaging with a plurality of splines on an un-shown assembly tool. Alternatively, tool-engaging portion 78 may comprise of a standard tool interface pattern such as that found on an Allen or Torx wrench. Regardless of the shape, cup tool-engaging portion 78 is larger in diameter than

bolt tool-engaging portion 73, such that the tool for tightening bolt 70 may pass through cup tool-engaging portion 78 without interference.

The purpose of cup 75 is to act as an axial stop element for bolt 70. In this manner bolt 70 contacts cup 75 when bolt 70 is loosened and thus pushes non-drive crank arm 60 off of spindle 50. Thus crank assembly 20 is easily disassembled for maintenance. To accomplish this it is important that the friction present between bolt outer side surface 71b and cup inner side surface 77a is smaller in magnitude than the friction present between cup threaded portion 76 and non-drive crank arm threads 68. This may be accomplished through the use of a friction modifying coating on either cup 75 or bolt 70, such as PTFE impregnation. In an alternative embodiment, a friction-reducing washer may be disposed between bolt 70 and cup 75.

It should be noted that cup 75 is shown in this preferred embodiment but additional embodiments of the present invention may not use cup 75. In this instance, an un-shown disassembly tool may be used to remove non-drive crank arm 60 from spindle 50. Thus cup 75 is not a requirement for the proper operation of crank assembly 20 but does simplify its disassembly.

Figure 8 is an isometric partial cross-sectional view of an alternate embodiment of drive crank arm 40 and integrated spindle 50 shown in Figure 5. In this embodiment spindle 500 is integrally bonded with drive crank arm 400 which is made from a fiber-resin composite material. Drive crank arm 400 comprises pedal adapting portion 401, fiber-resin composite shell 402, and interior foam portion 403. Support projections 408 are provided on either drive crank arm 400 or spindle 500 for attaching at least one chainwheel 49 for driving a chain 13 to propel bicycle 10.

Spindle 500 comprises drive adapting portion 501, bearing race portions 502a and 502b, shoulder portion 503, non-drive adapting portion 504, and threaded portion 505. In this particular embodiment drive adapting portion 501 comprises a smooth continuous surface upon which are formed a plurality of un-shown protrusions. Fiber-resin composite shell 402 of drive crank arm 400 is formed over interior foam portion 403 and drive adapting portion 501 of spindle 500 and cured, such that spindle 500 is integrally bonded with drive crank arm 400 in a non-rotatable manner. Apart from this difference in construction, drive crank arm 400 and spindle 500 are identical to the embodiments shown in Figure 5.

Figure 9 is an isometric partial cross-sectional view of another alternate embodiment of drive crank arm 40 and integrated spindle 50 shown in Figure 5. In this embodiment spindle 510 is monolithically formed with drive crank arm 410 using common three-dimensional forming technology such as forging or casting. Drive crank arm 410 comprises pedal adapting portion 411, crank arm portion 412, and monolithically integrated spindle 510. Support projections 418 are provided on either drive crank arm 410 or spindle 510 for attaching at least one chainwheel 49 for driving a chain 13 to propel bicycle 10.

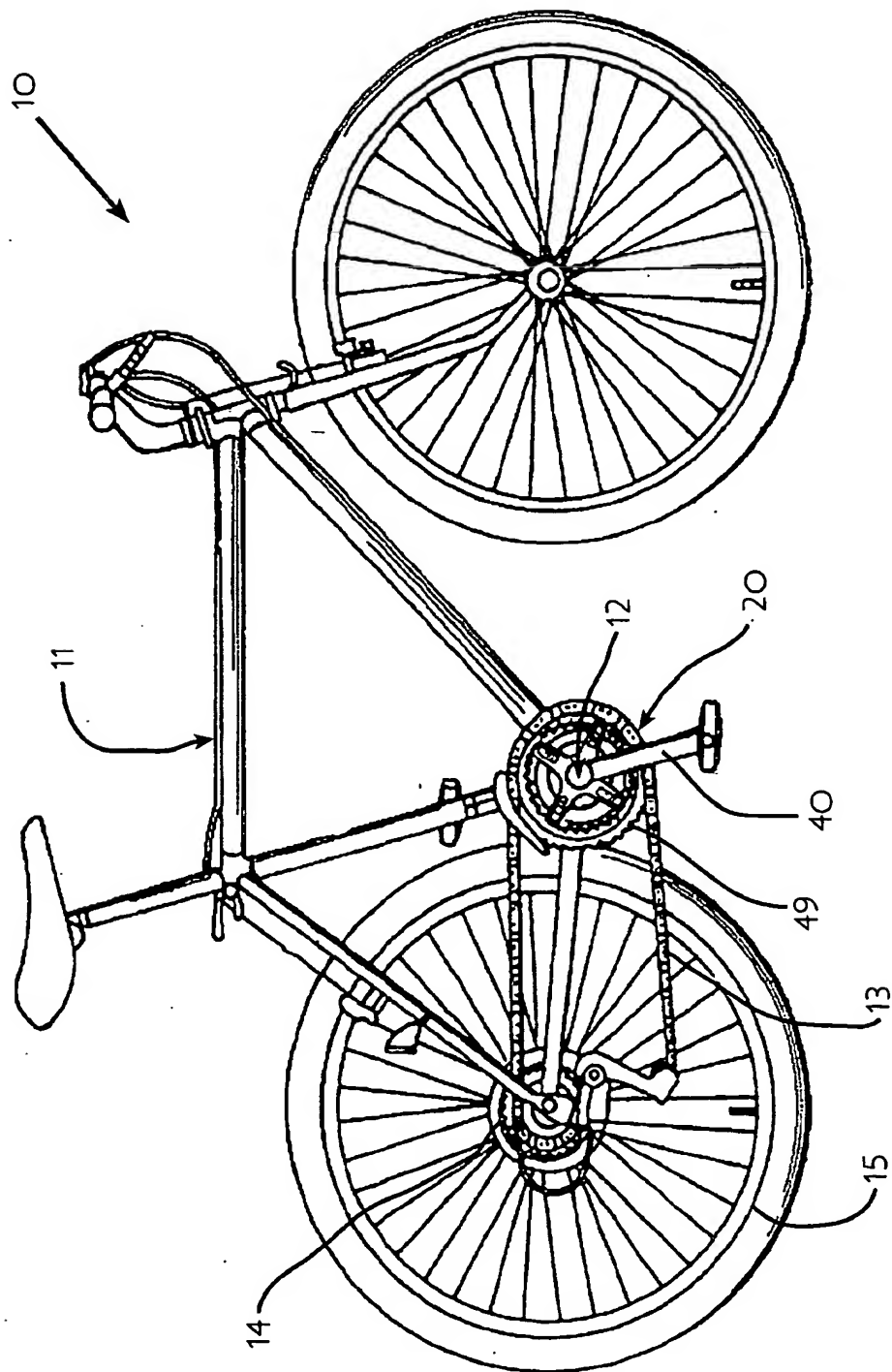
Spindle 510 comprises bearing race portions 512a and 512b, shoulder portion 513, non-drive adapting portion 514, and threaded portion 515. Apart from the difference of spindle 510 being monolithically formed with drive crank arm 410, drive crank arm 410 and spindle 510 are identical to the embodiments shown in Figure 5.

The assembly procedure for the preferred embodiment of the present invention will now be described. Spacer tube 39 is installed into bearing assembly 30a and then

bearing assemblies 30a and 30b are screwed into frame shell 12. Thus spacer tube 39 is disposed between bearing assemblies 30a and 30b and serves to seal the bearing assemblies from any contamination that enters frame shell 12. Integrated spindle 50 on drive crank arm 20 is then inserted through bearing assembly 30a and bearing assembly 30b until shoulder portion 54 contacts flange portion 33a of bearing reducer 33. Non-drive crank arm 60 is then installed onto non-drive adapting portion 55 of spindle 50. Bolt 70 is threaded into spindle threaded portion 56 and tightened, drawing crank arm 60 onto spindle 50 until inner side surface 64a contacts seal 90. As bolt 70 is tightened, washer 74, non-drive crank arm 60, seal 90, bearing 31b, and bearing reducer 33 are clamped tightly between bolt flange 71 and spindle shoulder 54.

The present invention therefore has a number of desirable and novel properties. Crank assembly 20 is rotatably mounted to frame shell 12 by both bearing assemblies 30a and 30b but fixed in an axial direction only by bearing assembly 30b, which is located farthest from chainwheel 49. Bearing assembly 30a, which is located closest to chainwheel 49, is not constrained in an axial direction on spindle 50 such that it can only carry radial loads. Thus, bearing loads are balanced between bearing assemblies 30a and 30b such that bearing life is maximized. Additionally, tolerances associated with differing lengths of frame shell 12 do not affect axial bearing loads because bearing assembly 30a is free to move in an axial direction on spindle 50 to accommodate for these different lengths. Further, there is no need for the assembler to manually adjust the axial distance between bearing assemblies 30a and 30b to satisfy a pre-determined axial bearing load allowance. In this way, bearing assemblies 30a and 30b are not subjected to axial force as a result of installation and their service life is not affected by assembly

practices. Finally, assembly and disassembly of the entire system is quick and simple with a minimum of required tools.



**Figure 1**

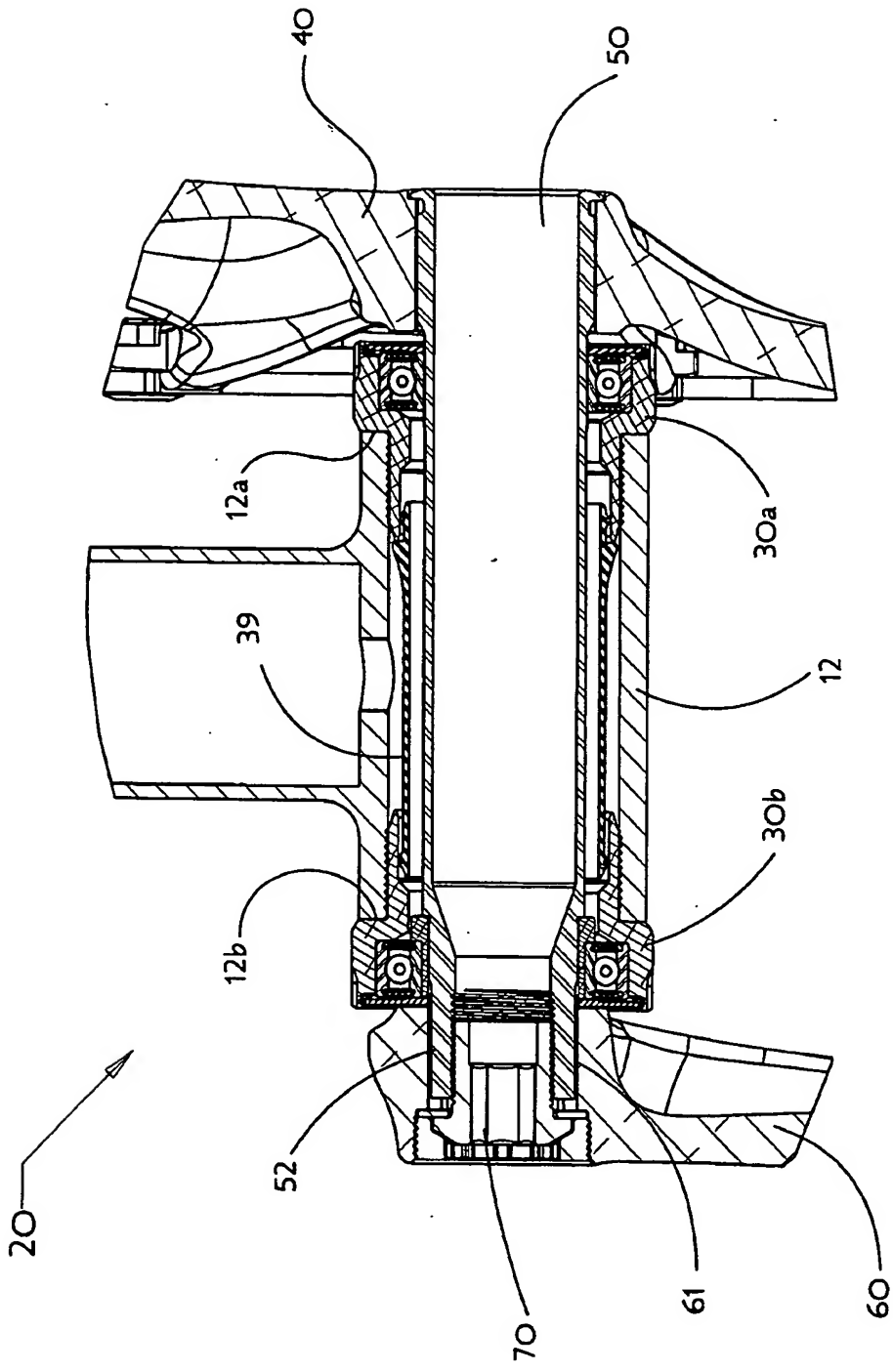


Figure 2



Figure 3A

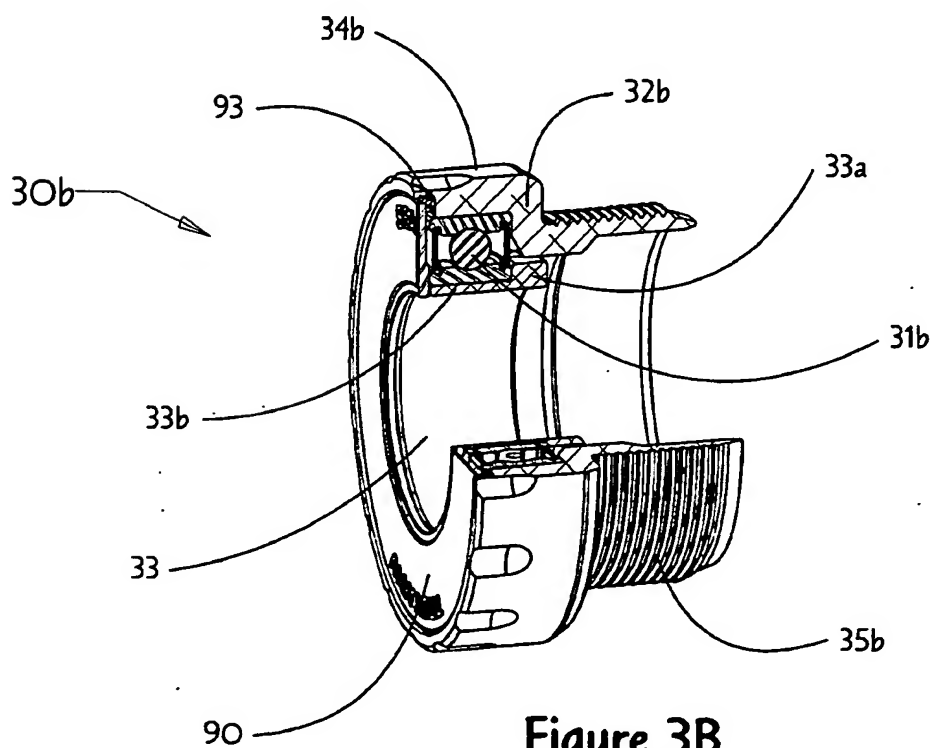
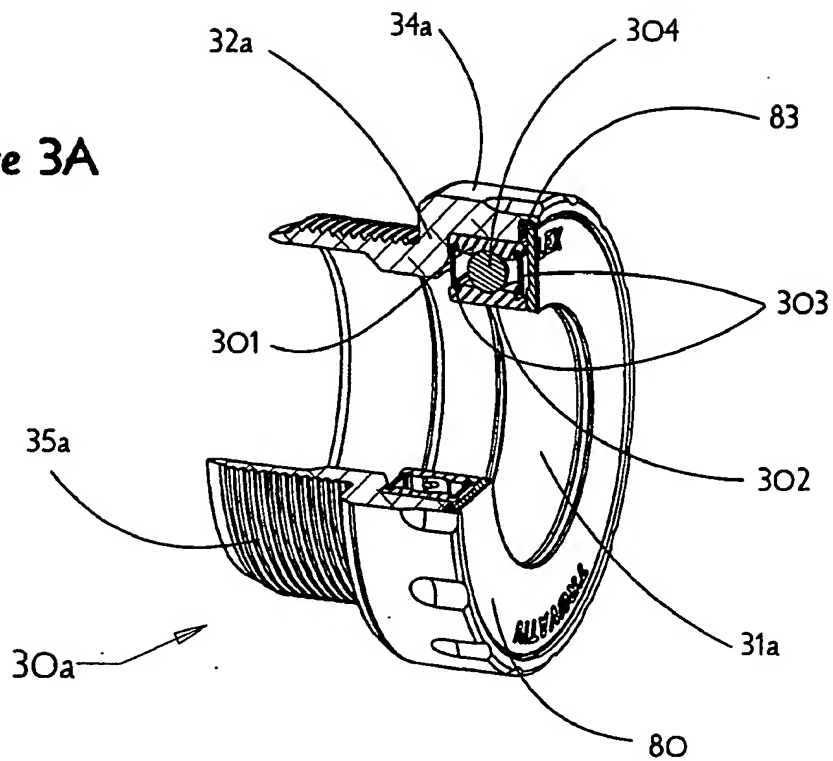


Figure 3B

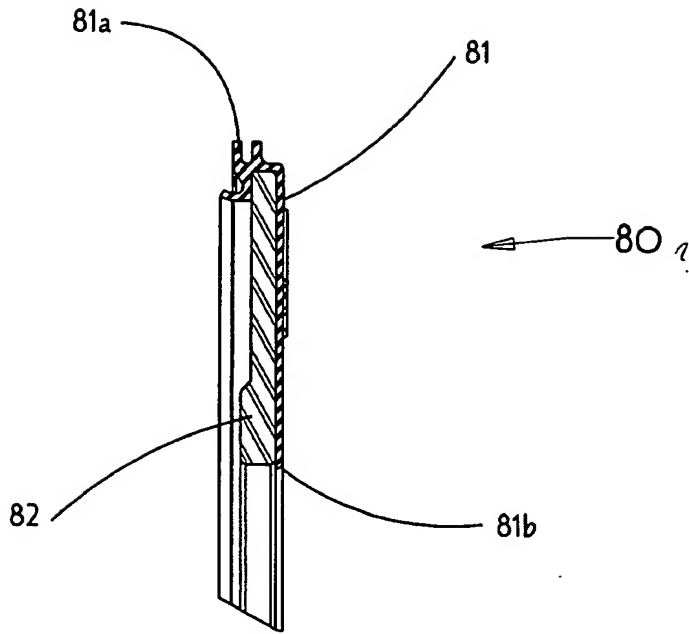


Figure 4A

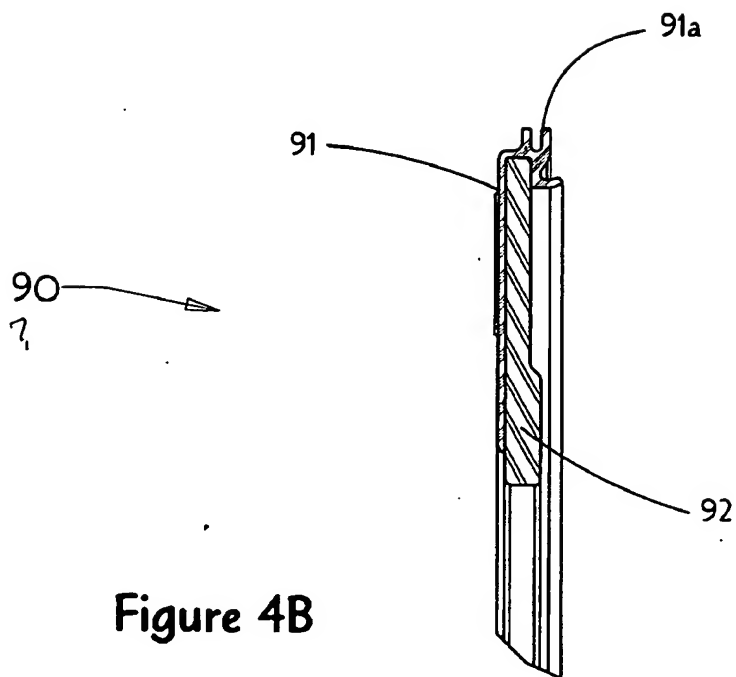


Figure 4B

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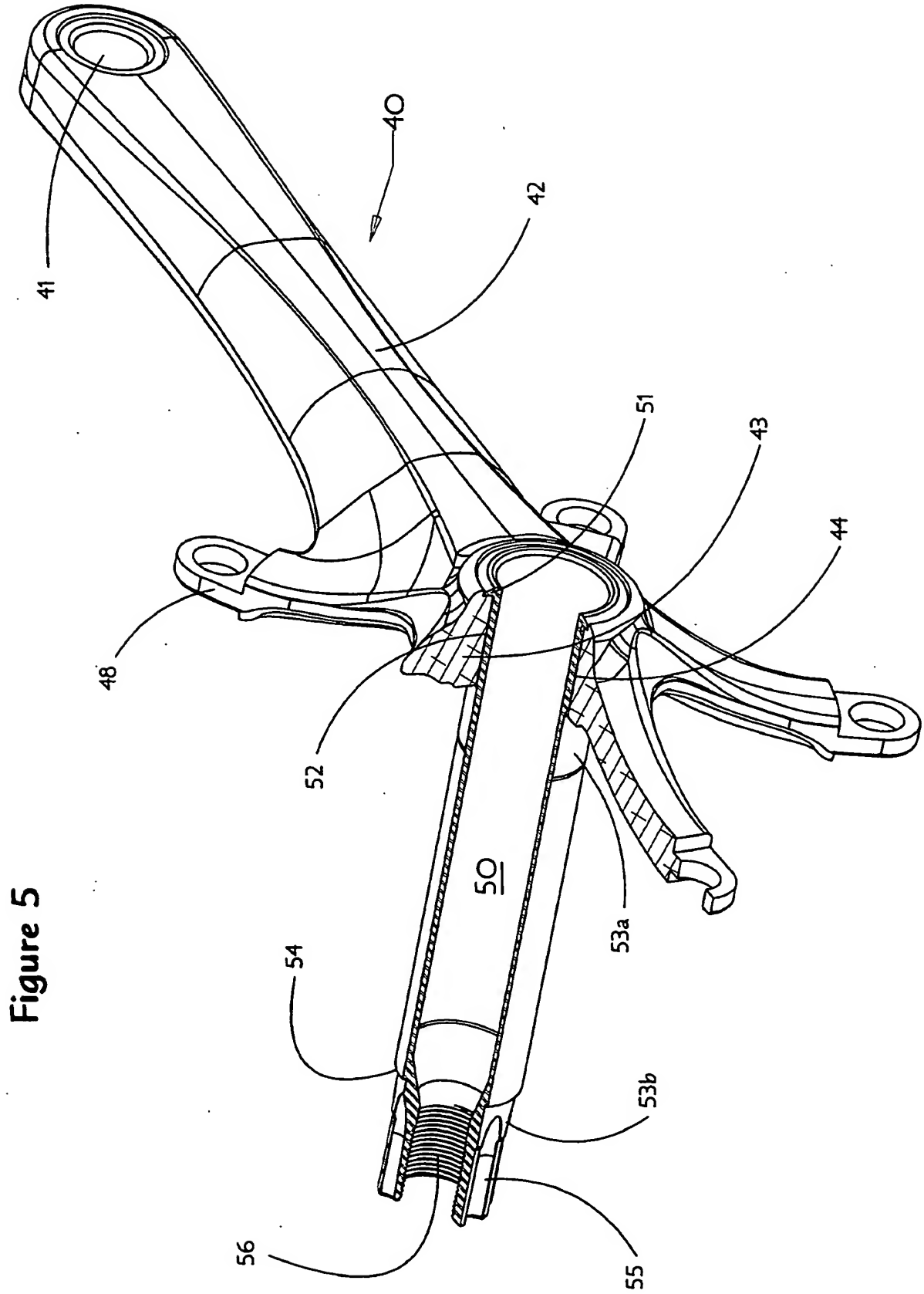


Figure 5

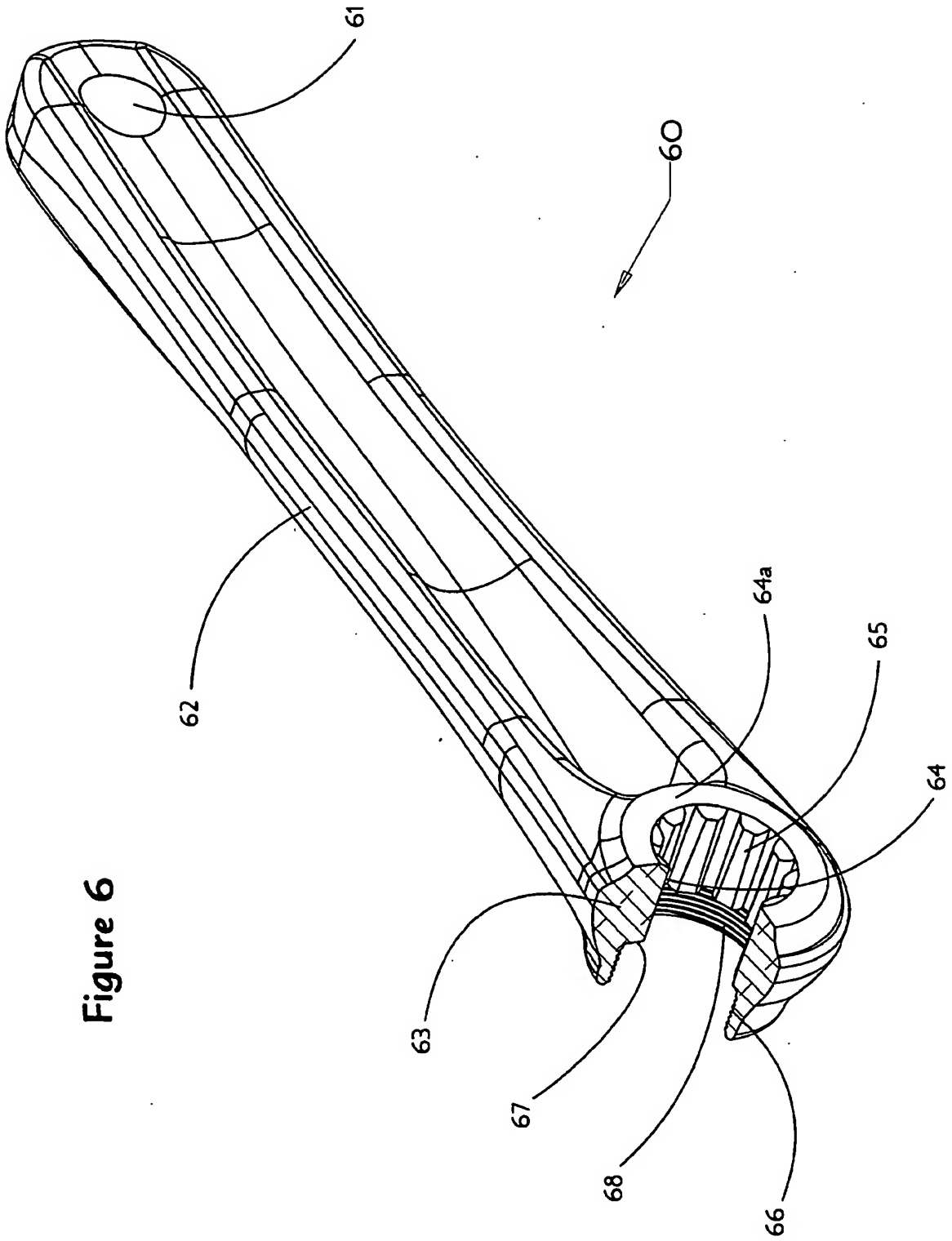


Figure 6

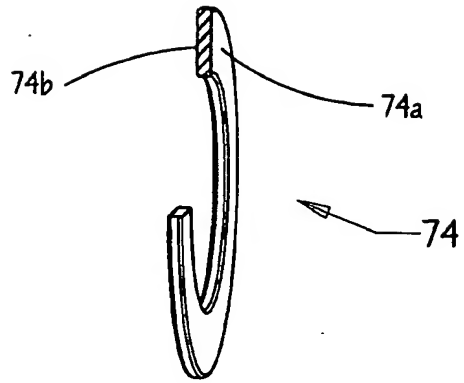


Figure 7A

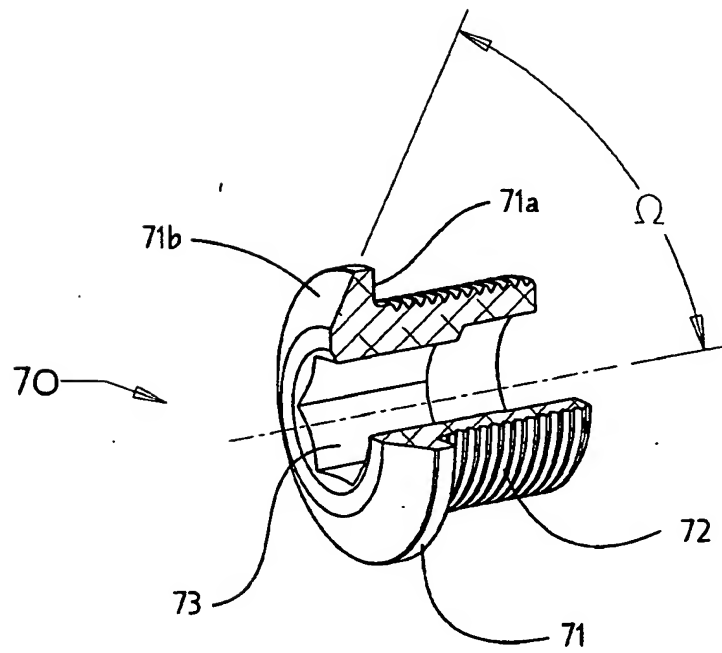


Figure 7B

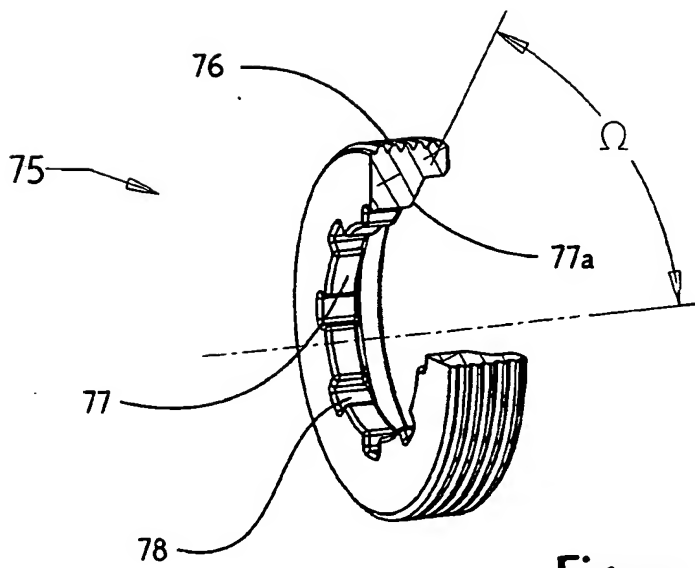
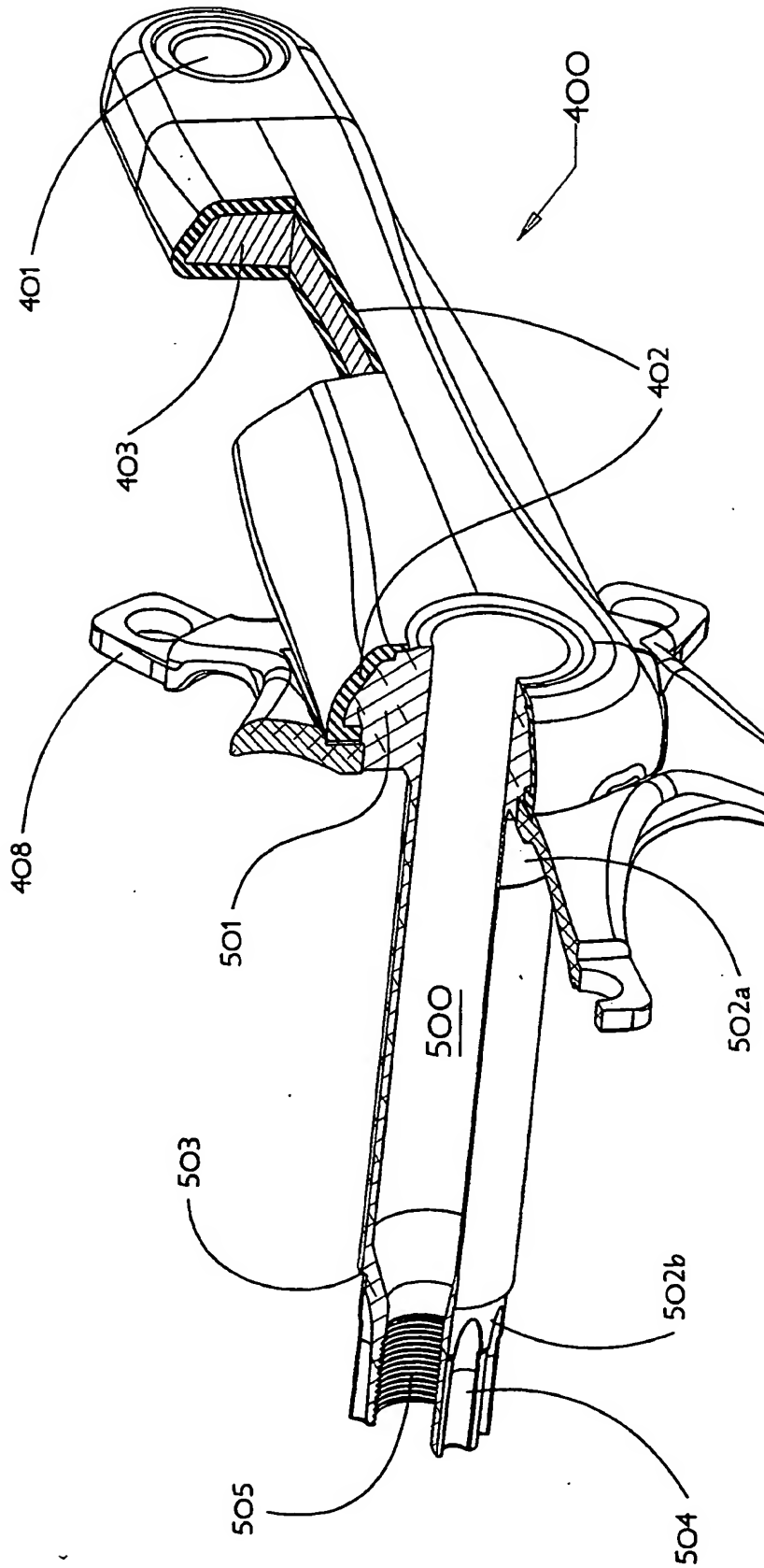


Figure 7C



### Figure 8

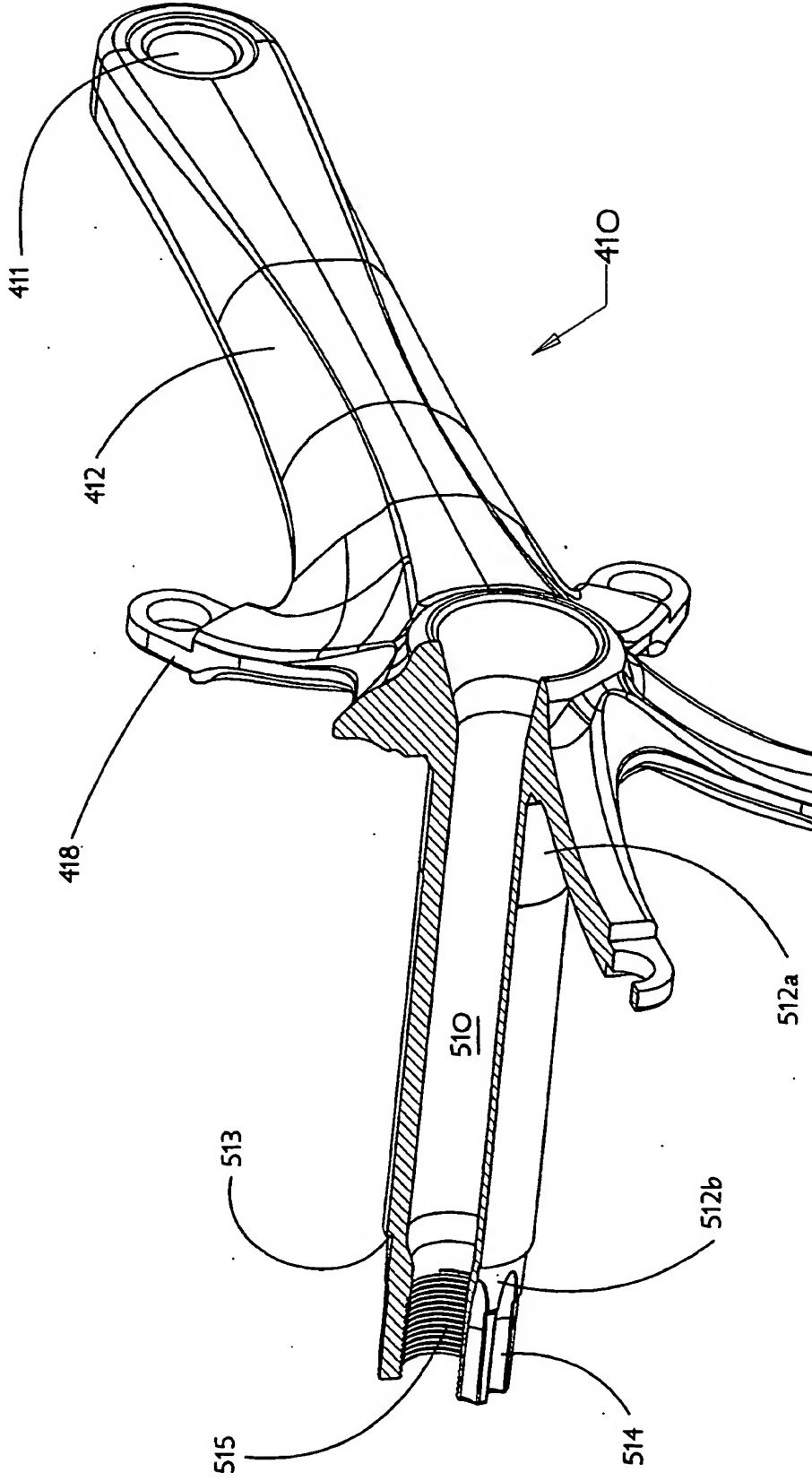


Figure 9

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